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RAPESEED MEAL IN DIETS FOR SWINE REPRODUCTION

by



Hugh Simon Saben

A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Rapeseed Meal in Diets for Swine Reproduction" submitted by Hugh Simon Saben, B.Sc., in partial fulfilment of the requirements for the degree of Master of Science.

Date

June 26, 1970

ABSTRACT

An experiment was designed to study the effects of substituting 4 or 8% commercial solvent-extracted rapeseed meal (RM) for equivalent levels of soybean meal (SM) in the diets of sows during gestation, lactation or both for two reproductive cycles. Thirty-two gilts were allotted to 4 dietary treatments, (0, 4 or 8% RM throughout the experiment or 8% RM fed for the first 100 days of gestation followed by 0% RM). The gilts were assigned to the dietary treatments at an average of 83 kg liveweight and 163 days of age.

Feeding RM did not influence daily gain or feed required per kg gain from 83 kg to the first breeding or during the two gestation periods. No effects of dietary RM were noted on the number of services to conception or the length of gestation. No significant differences were noted in the number of pigs born, number of pigs born alive, number of pigs weaned, litter birth weights, litter weaning weights, pig birth weights or pig weaning weights. Changing the diet of sows from 8% RM to 0% RM after 100 days of gestation did not influence any of the reproductive traits being studied.

Significant differences in favor of crossbred sows were obtained between the two breeding groups, namely the Lacombe x Yorkshire and the Yorkshire, in daily gain from 83 kg liveweight to the first breeding, breeding weight in both gestation periods and pig weaning weight for the second lactation period. However, the Yorkshire sows showed a significant improvement over the crossbreds in individual pig birth weights for the first reproductive cycle.

It may be concluded that a level of 8% commercial solvent-extracted RM in the diets of gestating and lactating sows is acceptable as a substitute for an isonitrogenous level of SM.

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INTRODUCTION

Rapeseed meal (RM) is a by-product from processing of rapeseed to produce rapeseed oil. In the last decade the Western Canadian rapeseed acreage has increased dramatically. Two million acres were planted which produced 37,000,000 bushels in 1969. Eighty percent of the crop is exported with Japan being our major buyer, with the remaining 20% of the crop being used in the domestic production of oil and meal.

Commercial production of rapeseed in Canada is of rather recent origin. About twenty years ago, the crop was introduced to provide a domestic source of oil to replace the imports of other edible oils. Since rapeseed contains approximately 40% oil with the remainder being meal plus moisture, the extraction of the seed results in the production of large quantities of RM.

RM contains, on the average 35% crude protein, 13% crude fibre, 0.6% calcium, 1.0% phosphorus and 2.0% lysine. Expressed as a percentage of protein this is equivalent to 5.7% lysine. With the relatively high protein content of RM, it is a potential substitute for soybean meal (SM) in livestock and poultry diets. Its use in swine diets was limited by regulation of the Feeds Act until 1966. At that time restrictions were removed because research had demonstrated that its use in most swine diets would cause no adverse effects. This change in quality of RM was associated with improved processing techniques by the Canadian processors.

Two species of rapeseed are grown in Canada: The Polish type Brassica campestris and the Argentine type Brassica napus. More of the Polish variety is now grown in Canada due to the fact that this type

has earlier maturity than the Argentine type. B. campestris also has a lower thioglucoside (glucosinolate) content than the Argentine variety.

Research information on the use of RM in diets for swine reproduction is limited and inconsistent. This may be in part associated with the improvement in the quality of the meals being processed, which means that research conducted prior to 5 or 6 years ago is largely of historical interest. Therefore, studies were undertaken to determine what effects, if any, there were from including commercial solvent-extracted RM in swine diets for reproduction and lactation. This experiment was conducted at the University of Alberta Livestock Farm from May 1968 to June 1969.

REVIEW OF LITERATURE

A. Introduction

The growing of rapeseed may be one way to alleviate the existing excess of wheat in Canada, in that the producer could grow rapeseed in place of wheat. However, there must be a market for rapeseed and its by-products or it cannot be justified as a Western Canadian crop. There is a reluctance to use RM in swine diets due to reports of adverse effects of the meal on reproduction and lactation.

B. 1. Nature of undesirable properties: The goitrogens

Rapeseed and RM contain goitrogens. Chesney, Clawson and Webster (1928) produced the first evidence of a goitrogen in food. They fed fresh cabbage, oats and hay to 486 rabbits and found that 440 rabbits or 90% had thyroids weighing an average of 0.5 g which was about twice the average thyroid weight (0.23 g) of the normal rabbits. One animal after being fed the ration for 428 days had a thyroid weighing 43 g, or a 200-fold increase.

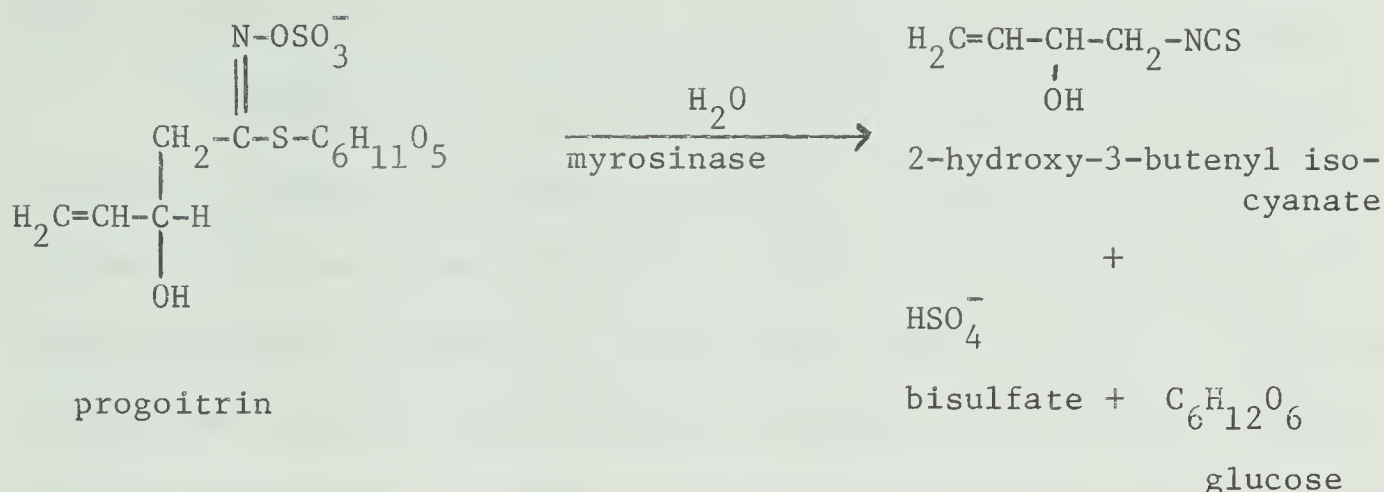
Kennedy and Purves (1941) appear to have been the first workers reporting goitrogenic factors in ground rapeseed. They fed Wistar strain young albino rats a diet containing rapeseed and found that the thyroid increased 138% in size over the first 21 day period, then the thyroid reached a plateau, and its continued growth was in proportion with the continued growth of the rat. Blakely and Anderson (1948) reported on the goitrogenicity of RM for turkey poults which had enlarged thyroids when the meal was fed. Clandinin and Bayly (1960) reported that when expeller RM was fed to chicks, the thyroid-to-body-weight ratio doubled when a dietary level of 15% Polish type

or of 5% Argentine type was used. The difference between the two types of meal was due presumably to the difference in the goitrogen content, with the Argentine type being higher. Similar results were obtained by Manns and Bowland (1963) with pigs and rats and by Bowland and Standish (1966) with rats.

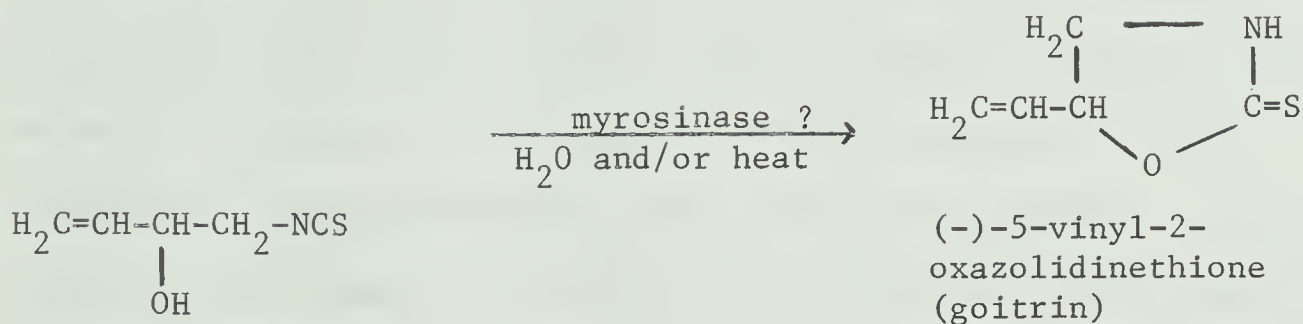
The undesirable principles in RM are derived mainly from thioglucosides which yield isothiocyanates and oxazolidinethione on enzymatic hydrolysis by myrosinase. These thioglucosides, or related compounds, are characteristic of the Cruciferae, or mustard family, to which the genus Brassica belongs (Bell and Belzile 1965).

The main goitrogen in rapeseed was isolated and identified by Astwood, Greer and Ettlinger (1949a) as L-5-vinyl-2-thiooxazolidone and called goitrin. This goitrin has been assigned the chemical name (-)-5-vinyl-2-oxazolidinethione (Greer 1962). Goitrin occurs as a thioglucoside (glucosinolate has become the preferred nomenclature, Ettlinger and Kjaer, 1967) in rapeseed, which on hydrolysis by the enzyme myrosinase breaks down to yield glucose, bisulfate and 2-hydroxy-3-butenyl isothiocyanate (Greer 1956, Virtanen 1965). This latter compound is an unstable, volatile allyl isothiocyanate and on further treatment with myrosinase and/or heat cyclizes to form (-)-5-vinyl-2-oxazolidinethione (Kjaer 1960), which is the main goitrogen. The two reactions involved are as follows:

First reaction:



Second reaction:



2-hydroxy-3-butenyl isothiocyanate

Thus as Clandinin, Renner and Robblee (1959) observed, heat will increase the goitrogenicity of RM by converting the volatile isothiocyanate to the cyclic non-volatile goitrin, (-)-5-vinyl-2-oxazolidinethione.

2. Action of undesirable properties

Hussar and Bowland (1959) and Manns et al. (1963) showed that rats fed 10% RM had a decrease in their standard metabolic rate, which is regarded as one of the most useful methods of estimating levels of thyroid activity. As the levels of RM increased in the diet the standard metabolic rate decreased. These authors further showed that

the serum protein bound iodine was reduced in swine when RM was fed from weaning at 21 days of age to market weight at 90 kg liveweight.

Griesbach and Purves (1943) and Purves (1943) showed that in rats the feeding of rapeseed seemed to interfere with the ability of the thyroid to produce thyroxine, with the result that there was a reduced amount of thyroxine in the blood. Thus it seems that goitrogens in rapeseed interfere with thyroxine synthesis, and that the anterior pituitary gland which produces the thyroid stimulating hormone (TSH) causes thyroid hypertrophy and hyperplasia. This reduced secretion of TSH could be due to lack of iodine. The goitrogen apparently interferes (Greer 1962) with the organic binding of iodine in the molecular coupling of two iodinated tyrosine molecules to form thyroxine or triiodothyronine, which are thyroid hormones. Greer (1962) further showed, that the only goitrogens that have significant antithyroid activity are those capable of cyclizing to form (-)-5-vinyl-2-oxazolidinethione. Few antithyroid substances are capable of blocking the action of thyroxine once it has been excreted from the thyroid gland.

A recent observation (Personal Communication, 1970, to J.P. Bowland from J. Devilat, Instituto de Investigaciones Agropecuarias, Santiago, Chile) of typical symptoms of iodine deficiency in newborn pigs from gilts fed 12% RM supports the hypothesis proposed by Greer (1962) for the action of the goitrogens in RM.

There is little evidence to show detrimental goitrogenic action from feeding RM to ruminants (Whiting 1965). Numerous workers (Witz, Carpenter and Hayward, 1950, Dow and Allen, 1954, Klain et al. 1956, Clandinin, Renner and Robblee, 1959) all reported increased

thyroid size when RM was fed to poultry.

C. 1. Nutritive value of rapeseed meal: Processing methods

In processing RM, the thioglucoside content will be activated or deactivated by myrosinase and/or heat. High temperature and high moisture content of the meal will lead to rapid hydrolysis of the thioglucosides to the isothiocyanates (Mustakas, Kirk and Griffin, 1962).

Thus to avoid this increase in isothiocyanate level only solvent or prepress-solvent extraction processes are now presently used. Recent studies have shown that present meals are almost myrosinase-free, (Bell and Belzile, 1965) and thus contain unhydrolyzed thioglucosides.

Clandinin, Renner and Robblee (1959) showed that at temperatures over 100°C there was a drastic reduction in the lysine content of the protein in the resultant meal. Clandinin (1967) found an average of $5.72\% \pm 0.26$ available lysine (expressed as a percent of protein) from solvent-type meals and $5.68\% \pm 0.30$ available lysine from prepress-solvent meals. Finlayson (1965) reported a lysine content of 6.6% for solvent-extracted meal. Both Clandinin and Finlayson indicate little loss of lysine using these processes. However using an expeller-type produced meal, Clandinin (1967) obtained a value of $4.44\% \pm 0.86$ available lysine; this lower value could be due to heat damage to the protein (Bell and Belzile 1965).

2. Nutritive value of rapeseed meal: Reproduction and lactation

Frölich and Haring (1937) stated that 400 g of RM per head per day was acceptable for nursing sows, and only half this amount was

acceptable for young gilts. Bell (1958), cited by Bell and Belzile (1965), obtained adverse results when a level of 7% RM (of either the Argentine or Polish type) was fed to pregnant gilts. RM at this level reduced litter size and impaired lactation. Gilts were physically weak after farrowing. The weight loss during lactation was greater for the RM-fed gilts than the control groups with no RM in their diets. The above observations were especially noticeable when the Polish type was fed.

Manns and Bowland (1963) fed RM to gilts in gestation and lactation diets at 3, 6 and 12% of the ration. At the latter two levels of meal the gilts required 2 to 2.5 estrus cycles to conceive, but gilts were bred only once per cycle. Similar results were obtained with rats fed the same diets. The addition of 0.2% supplemental L-lysine to the diets was of no benefit. Kennedy and Purves (1941) reported that RM delayed ovarian development, and this could be one explanation for the poor conception obtained by Manns and Bowland. Schuld and Bowland (1968) showed no difference in the number of services to conception when they fed 8% RM to gilts, but their gilts were bred twice in each estrus cycle.

Manns and Bowland (1963) fed RM to gilts that had an average of 5.6 g of oxazolidinethione and 4.2 g of isothiocyanate per kg of meal, however Schuld and Bowland (1968) were feeding a meal that had an average of 1.7 g of oxazolidinethione and 6.8 g of isothiocyanate per kg of meal. The difference in oxazolidinethione content between the meals could explain the difference in number of services for conception.

Hussar and Bowland (1959) and Manns and Bowland (1963) noted no reduction in feed intake or gain during the pre-gestation period

from 83 kg to the first breeding, when RM was fed to gilts. However Schuld and Bowland (1968) did observe a significant decrease in feed intake when similar levels of RM were substituted for SM in the diets of gilts. These differences are not readily explained on the basis of chemical composition of the meals.

When Manns and Bowland (1963) fed 12% RM to gilts they noted that the numbers of live pigs farrowed were similar to the groups not fed RM, but that there was a decrease in the birth weight and the weaning weight of the pigs from the gilts fed RM. Similar results were obtained by Schuld and Bowland (1968). These workers suggest that these decreases could be due to lactational inadequacy associated with dietary RM, as has been reported by Bell and Baker (1957) for mice.

In a review article, Bowland (1965) suggests that in the diets of swine breeding stock during pre-gestation, gestation and lactation RM should not exceed 3% of the total ration. Schuld and Bowland (1968) observed that 8% RM in the diets of breeding stock did not influence reproductive performance of gilts or their litters during two reproductive cycles. However, feeding 8% RM in the growing period of these gilts did affect daily gain and feed required per kg of gain from 90 to 106 kg liveweight, as well as reproductive performance during their first reproductive period.

Robblee (1965) in a review article summarizes the status of RM as a protein supplement: Advances have been made within the last few years to alleviate the possible adverse effects of thioglucosides in RM, also new and improved processing methods now employed are responsible for producing a more even quality product. It has recently been observed by Drouliscos and Bowland (1969) that: "If satisfactory

methods can be devised to remove the hull from rapeseed meal, and hence lower the fibre content, and if goitrogens can be removed genetically or chemically, it is probable that this meal would be markedly improved as a protein source for animal and human nutrition. With present research in progress on rapeseed meal, such modifications of the meal appear to be feasible in the near future".

EXPERIMENTAL

Objectives

An experiment was designed to study the effects of substituting 4 or 8% solvent-extracted rapeseed meal for equivalent levels of soybean meal (SM) in the diets of gilts during gestation, lactation or both for two reproductive cycles.

Methods and Procedures

1. General

The experiment was conducted from May 1968 to June 1969 at The University of Alberta Livestock Farm. The study dealt with reproductive performance of 32 gilts through two reproductive cycles. The following data were collected: Daily feed (kg); Daily gain (kg); Feed required per kg gain (kg); Number of services to conception; Breeding weight (kg); Total gestation weight gain (kg); Length of gestation (days); Lactation weight loss (kg); Number of pigs born; Number of pigs born alive; Number of pigs weaned; Litter birth weight (kg); Litter weaning weight (kg); Pig birth weight (kg); Pig weaning weight (kg).

2. Formulation of experimental diets

Diets were formulated (Table 1) to meet requirements as defined in the National Academy of Sciences - National Research Council Nutrient Requirements of Swine (1968)¹. RM diets were adapted

¹ As a member of the Subcommittee on Nutrient Requirements of Swine, J.P. Bowland provided the requirement data in advance of publication of the Bulletin in 1968.

Table 1. Composition of the diets¹ on an air-dry basis

Level of RM %	0	4	8
Fed to Lots	1 & 3	2	3 & 4
<u>INGREDIENTS</u> %			
Wheat	26.50	26.00	25.50
Barley	26.95	26.95	26.95
Oats	30.00	30.00	30.00
Alfalfa Meal	4.00	4.00	4.00
Soybean Meal (44%)	9.00	5.50	2.00
Rapeseed Meal	—	4.00	8.00
Meat Meal (50%)	2.00	2.00	2.00
Dicalcium Phosphate	0.30	0.30	0.30
Vitamin B ₁₂	0.05	0.05	0.05

¹ In addition all diets contained 0.5% ground limestone, 0.5% iodized salt, 0.1% trace mineral mix and 0.1% vitamin B complex mix and vitamins A and D.

The mineral mix contained the following per kg: Cobalt carbonate 2.28 g; Copper sulfate 24.50 g; Ethylene diamine dihydroiodide 1.30 g; Ferrous carbonate 234.80 g; Manganous oxide 47.73 g; Zinc oxide 2.96 g; Ground limestone 686.43 g.

The B-vitamin mix contained the following per kg: Riboflavin 4.4 g; Calcium pantothenate 8.8 g; Niacin 19.8 g; Choline chloride 21.4 g; Folic acid 132.0 mg.

Vitamin A was fed at 500,000 IU and Vitamin D₂ at 50,000 IU per 100 kg of diet.

from the basal diet by substituting RM for wheat and SM so that the diets were isonitrogenous and approximately isocaloric.

The diets on an air-dry basis (Table 2) contained on an average 3078 kcals digestible energy (DE) per kg, 15.8% crude protein and 0.68% lysine.

The RM used throughout the experiment contained on an average 2.40 g oxazolidinethione and 2.60 g isothiocyanates per kg of meal. The oxazolidinethione was determined by the method of Astwood, Greer and Ettlinger (1949b). The isothiocyanates were determined by the method of Wetter (1955). The RM in the present study was lower in isothiocyanates than those used by Schuld and Bowland (1968) and Manns and Bowland (1963), where the RM had 6.8 and 4.2 g isothiocyanates per kg of meal respectively. However Schuld and Bowland (1968) reported only 1.7 g oxazolidinethione per kg of meal, while Manns and Bowland (1963) fed meal containing 5.6 g oxazolidinethione per kg.

All diets were mixed at The University of Alberta Livestock Farm elevator in one ton batches which were stored in bags at the experimental unit where the experiment was conducted.

3. Allotment of gilts and methods of feeding

Thirty-two gilts (eight littermate groups of four gilts each) were allotted to four dietary treatments for reproduction studies at an average of 83 kg liveweight and 163 days of age. Eight gilts, 4 Lacombe x Yorkshire and 4 Yorkshire, were assigned to each lot on the basis of litter origin (Table 3). Lot 3 was included in which sows were fed 8% RM to the 100th day of each gestation and then transferred to 0% RM, so that any effects of this level of RM during gestation only could be

Table 2. Composition of diets on an air-dry basis

Level of RM %	0	4	8
Fed to Lots	1 & 3	2	3 & 4
COMPOSITION			
Gross energy kcal/kg (analysis)	4130	4090	4035
Digestible energy kcal/kg (calculated) ¹	3120	3090	3050
Crude protein % (calculated)	16.0	16.0	16.0
Crude protein % (analysis)	15.7	15.8	15.8
Lysine % (calculated)	0.72	0.70	0.66

¹ Value obtained from Schuld, F.W. 1967. Rapeseed meal for swine reproduction. M.Sc. Thesis. The University of Alberta, Edmonton, Alberta.

Table 3. Allotment of sows¹ in rapeseed meal experiment

Lot number	Dietary RM (%)	
	Gestation	Lactation
1	0	0
2	4	4
3	8 ²	0
4	8	8

¹ There were 8 gilts, 4 each of Lacombe x Yorkshire and of Yorkshire in each lot.

² For the first 100 days of each gestation period.

ascertained. Prior to allotment the gilts were fed standard University of Alberta swine rations which contained wheat, barley, fishmeal, meat meal, SM and were balanced to meet requirements as defined in the National Academy of Sciences - National Research Council Nutrient Requirements of Swine (1964). These rations contained approximately 20% crude protein in the starting, 17% protein in the growing and 15% protein in the finishing periods.

Gilts were housed in groups of four in 1.8 x 3.1 m pens in a concrete-floored barn but were individually fed an average of 1.6 kg twice daily, (in the morning and afternoon), during the pre-gestation period until an average liveweight of 106 kg was attained. At this weight they were transferred to outside drylot pens where they were individually fed at a level of 2.7 kg per day. This level of feeding was continued until 3 weeks after breeding. During the remainder of the gestation period, feed was restricted to 2.3 kg per day. During lactation each sow was fed 2.3 kg per day plus 0.3 kg of feed per pig in her litter. These levels were based on the National Academy of Sciences - National Research Council Nutrient Requirements of Swine (1968).

4. Reproduction experiment

Starting at an average age of 220 days, gilts were mated at their first estrus period. Breeding was continued over a period of 42 days allowing the possibility of two complete estrus cycles. During each estrus cycle the gilts were mated twice. Mating for second litters was in the first estrus period after weaning the first litters at 21 days of age. Yorkshire and Lacombe boars were balanced among the various groups for both breeding periods.

In both the first and second gestation periods, sows were placed in farrowing stalls 106 days after their last mating, and they were kept there until 21 days after farrowing, at which time the pigs were weaned and the sows were transferred to outside drylot facilities.

Young pigs were identified at birth by ear notching, and at 4 days of age were injected intramuscularly with 1 ml Imposil 200 (contains 200 mg of iron dextran per ml) to prevent anemia. Males were not castrated until after weaning at 21 days of age. After weaning pigs were treated for roundworms (ascarids) with a piperazine compound. Vaccination for erysipelas was not done until after weaning. Therefore the pigs were not unduly stressed prior to the completion of the experiment.

5. Methods of chemical analysis

The diets were analyzed for gross energy using a Parr Oxygen Bomb Calorimeter¹. Nitrogen analysis of the diets were done by the Kjeldahl method for nitrogen (AOAC, 1964). A commercial "Kel-Pak"² was used to supply the catalyst, and boric acid was used to retain the ammonia. Protein level was calculated from nitrogen using a conversion factor of 6.25.

6. Methods of statistical analysis

Data were analyzed statistically using The University of Alberta APL ANOVA2 STPl computer program. A probability of 0.05 was selected as the point of significance for the data. Missing values were

¹ Parr Instrument Company, Moline, Illinois. Temperature changes registered by a Brown Electronik Recorder manufactured by Minneapolis-Honeywell Regulator Company, Philadelphia, Pennsylvania.

² Matheson Scientific, East Rutherford, New Jersey. Supplies Hg catalyst, K_2SO_4 and $CuSO_4$.

replaced by the average value of the group from which the data were missing. In the analysis of variance, the error degrees of freedom was reduced by one for each missing value, (Steel and Torrie 1960).

RESULTS AND DISCUSSION

1. Performance of gilts during pre-gestation

No significant differences were noted (Table 4) in the pre-gestation period (83 kg liveweight to 1st breeding). Daily feed averaged 2.6 kg, daily gain 0.52 kg and feed required per kg of gain 5.06 kg. These results are in agreement with Hussar and Bowland (1959) and Manns and Bowland (1963) who also observed no significant differences during this period. However, the results differ from those of Schuld and Bowland (1968) who observed that the RM fed groups had a daily gain of 0.34 kg compared to the SM group which had a daily gain of 0.43 kg, furthermore the RM group required 8.23 kg of feed per kg of gain, while the SM group required significantly less feed per kg of gain at 6.71 kg.

Two gilts (one each from lots 2 and 3) died prior to mating. Postmortem examination indicated that osteodystrophy had occurred in one sow from lot 2, while the sow from lot 3 died from an internal hemorrhage.

2. Performance of sows during two reproductive cycles

No significant differences were observed during either gestation period in daily feed, daily gain or feed required per kg of gain (Table 4). During the 1st gestation the groups fed 4 or 8% RM had a daily gain of 0.48 kg compared with 0.50 kg for the SM group. The former treatments required an average of 4.97 kg of feed per kg of gain compared with 4.76 kg feed per kg gain for the control SM treatment. During the 2nd gestation the groups fed RM had a daily gain of 0.38 kg, which was the same as that for the SM group. The groups fed RM required 6.36 kg of feed per kg of gain compared with 6.26 kg

Table 4. Feed intake, daily gain and feed conversion of sows during pre-gestation and for two reproductive cycles¹

RM in diet %				
Gestation	0	4	8 ²	8
Lactation	0	4	0	8
Lot	1	2	3	4
83 kg to 1st breeding:				
No. of pigs	8	7	7	8
Daily feed, kg	2.58	2.55	2.62	2.63
Daily gain, kg	0.54	0.55	0.49	0.48
Feed per kg gain, kg	4.77	4.63	5.35	5.48
1st Gestation:				
No. of pigs	8	7	7	8
Daily feed, kg	2.38	2.38	2.38	2.38
Daily gain, kg	0.50	0.50	0.49	0.45
Feed per kg gain, kg	4.76	4.76	4.86	5.28
2nd Gestation:				
No. of pigs	8	6	7	7
Daily feed, kg	2.38	2.38	2.37	2.37
Daily gain, kg	0.38	0.36	0.34	0.43
Feed per kg gain, kg	6.26	6.61	6.97	5.51

¹ No significant differences were observed for any of the traits.

² RM was fed to 100 days after breeding and then this group was fed 0% RM, the control diet.

feed per kg gain for the SM-fed group.

During the 2nd gestation period two sows died, one from lot 2 due to osteoarthritis and one from lot 4 due to a pelvic injury. None of the deaths during the experiment were directly attributable to diet.

3. Reproductive performance - first litters

Reproductive performance of the sows and performance of their litters did not differ significantly for any of the factors studied (Table 5). The number of services to conception averaged 1.1 and did not differ between groups. This observation agrees with that of Schuld and Bowland (1968) but differs from that of Manns and Bowland (1963). The latter workers showed that sows fed 6 or 12% RM needed an average of 2.0 to 2.5 estrus periods for conception compared to 1.0 for the sows not fed RM. This difference may be due in part to the fact that Manns and Bowland mated the gilts only once per estrus cycle, while in this experiment the sows were mated twice and three sows were mated three times per estrus cycle. Another factor could be that Manns and Bowland fed RM containing 5.6 g oxazolidinethione per kg of meal, while Schuld and Bowland fed meal with a level of 1.7 g oxazolidinethione and a level of 2.40 g oxazolidinethione was used in this study.

There was a slight, but not significant, decrease in weight gain of sows during gestation as the level of RM increased in the diet. Gestation length of 114 days was the same for all groups.

The number of pigs born (10.3), number of pigs born alive (10.3) were slightly greater for sows fed the control diet without RM than for those fed the RM-containing diets which averaged 9.3 and 8.8 pigs respectively for these criteria. This increase in litter size was

reflected in a trend toward a higher litter birth weight for the control treatment although individual pig weights were similar for all treatments. However, these increases were not at a statistically significant level, and are probably due to the variation within each group. Because of the relatively small numbers involved, the possibility cannot be ruled out that a real difference existed which was not detectable statistically.

There were 8.3, 8.9, 7.6 and 7.5 pigs weaned per litter for treatments 1 to 4 respectively. Individual pig weaning weights were inversely related to the numbers of pigs weaned per litter.

Schuld and Bowland (1968) obtained a significant difference in the number of pigs born alive and the number of pigs weaned, in favor of the control group containing no RM contrasted with the RM-fed groups. However they were feeding RM that was higher in hydrolyzed thioglucoside, 6.8 g compared with a level of 2.6 g per kg of meal that was fed during the course of this study.

In a collaborative study conducted during 1969-70 under the auspices of the Rapeseed Utilization Assistance Program, (Weinberg, B., Personal Communication, 1970) eleven samples of RM processed by 5 processors by solvent, prepress-solvent or expeller processes were analyzed. The oxazolidinethione content of these meals following hydrolysis and addition of myrosinase ranged from 1.7 to 11.1 g per kg oil-free meal but 8 of the meals were between 1.7 and 2.6 g oxazolidinethione per kg of meal. This suggests that the majority of RM processed at present is similar in thioglucoside level to the meal fed in the present study. This observation is undoubtedly associated with the extensive use of Brassica campestris rather than B. napus as the source of RM.

Table 5. Reproductive performance-first litters¹

RM in diet %				
Gestation	0	4	8 ²	8
Lactation	0	4	0	8
Lot	1	2	3	4
Gestation:				
No. of services to conception	1.2	1.3	1.0	1.0
Breeding weight, kg	119	116	116	115
Total gestation weight gain, kg	59.4	56.6	55.6	50.8
Length of gestation, days	114	114	114	114
Lactation:				
No. of litters	8	7	7	8
Lactation weight loss, kg	15.8	16.7	14.1	16.9
No. pigs born	10.3	9.6	9.4	8.9
No. pigs born alive	10.3	8.9	9.1	8.4
No. pigs weaned	8.3	8.9	7.6	7.5
Litter birth weight, kg	13.2	11.1	11.3	11.3
Litter weaning weight, kg	38.4	41.6	43.7	37.8
Pig birth weight, kg	1.30	1.28	1.24	1.35
Pig weaning weight, kg	4.68	4.86	5.17	5.22

¹ No significant differences were observed for any of the traits.

² RM was fed to 100 days after breeding and then this group was fed 0% RM, the control diet.

4. Reproductive performance - second litters

During the second reproductive period, no significant differences in reproductive performance of the sows or performance of their litters were observed between any of the groups for any of the factors observed (Table 6). The number of services to conception averaged 1.1 and did not differ between groups. During the first reproductive period the number of services to conception averaged 1.1, showing good agreement over both reproductive periods.

The average length of gestation at 114.5 days was similar in the second reproductive period to the 114 day average gestation period in the first reproductive period.

The number of pigs born averaged 8.4 and the number of pigs born alive 8.2 for all treatments. The number of pigs born alive was 9.4 for the control group, which was 1.6 pig more than those fed RM. This is a similar result to that which occurred in the first reproductive period. The individual pig weaning weights which were 5.52 kg for the RM-fed groups and 4.89 kg for the control treatment, were slightly, but not significantly, greater for the groups fed RM. However, as in the first reproductive period the RM-fed groups weaned fewer pigs, 7.1 compared with 8.5 for the control group in lot 1.

5. Comparison of breeding groups

Significant differences between the two breeding groups of sows involved, namely the crossbred Lacombe x Yorkshire and the pure Yorkshire, were obtained in favor of the crossbreds in daily gain from 83 kg liveweight to the first breeding (Table 7). The crossbreds gained 0.59 kg per day compared with the Yorkshires which gained 0.45

Table 6. Reproductive performance-second litters¹

RM in diet %				
Gestation	0	4	8 ²	8
Lactation	0	4	0	8
Lot	1	2	3	4
Gestation:				
No. of services to conception	1.1	1.3	1.0	1.1
Breeding weight, kg	160	157	158	149
Total gestation weight gain, kg	43.0	40.5	38.9	49.3
Length of gestation, days	114	114	115	115
Lactation:				
No. of litters	8	6	7	7
Lactation weight loss, kg	14.3	16.7	19.3	19.9
No. pigs born	9.8	7.3	8.1	8.6
No. pigs born alive	9.4	7.2	7.9	8.4
No. pigs weaned	8.5	6.0	7.3	7.9
Litter birth weight kg	13.9	10.5	10.5	12.7
Litter weaning weight, kg	42.3	32.9	36.3	43.7
Pig birth weight, kg	1.48	1.48	1.41	1.60
Pig weaning weight, kg	4.89	5.50	5.17	5.90

1 No significant differences were observed for any of the traits.

2 RM was fed to 100 days after breeding and then this group was fed 0% RM, the control diet.

kg per day. This difference could be associated with heterosis or hybrid vigor in the crossbred gilts.

Lacombe x Yorkshire gilts were significantly heavier (121.4 kg) compared with the pure Yorkshire sows (111.9 kg) at the first breeding.

As the crossbreds were heavier at the first breeding this trend was continued at the second breeding, when they were 165.3 kg liveweight compared to the purebred sows that weighed 147.2 kg at that time. Also, the individual pig weaning weights in the second reproductive cycle were greater ($P < 0.05$) for the crossbreds, 5.8 kg compared to 5.0 kg for the purebred group. However, no difference was noted in the litter weaning weights between the two groups.

The purebred sows produced heavier ($P < 0.05$) individual pigs at birth than the crossbreds, 1.4 kg compared to 1.2 kg, in the first reproductive cycle. No explanation can be given for this observation.

Table 7. Comparison of means between Lacombe x Yorkshire and Yorkshire breeding groups. Significant differences ($P < 0.05$) only

Trait studied	Breeding Groups	
	Lacombe x Yorkshire	Yorkshire
Daily gain (83 kg to 1st breeding) kg	0.59	0.45
Weight at 1st breeding, kg	121.4	111.9
Pig birth weight 1st reproductive period, kg	1.2	1.4
Weight at 2nd breeding, kg	165.3	147.2
Pig weaning weights 2nd reproductive period, kg	5.8	5.0

GENERAL SUMMARY AND CONCLUSIONS

RM fed at levels of 4 and 8% in the diets of gestating and lactating sows for two reproductive periods caused no decrease in reproductive performance of the sows or in performance of their litters. The comparison was made with sows fed an isonitrogenous level of SM in their diets. Traits measured were number of pigs born, number of pigs born alive, number of pigs weaned, litter birth weights, litter weaning weights, pig birth weights and pig weaning weights. Changing the diet of sows from 8% RM to 0% RM after 100 days of gestation, did not influence reproductive performance.

It may be concluded that a level of 8% solvent-extracted RM in the diets of gestating and lactating sows is acceptable in substitution for an equivalent level of SM on an isonitrogenous basis.

BIBLIOGRAPHY

- Association of Official Agricultural Chemists. 1964. Official methods of analysis. 10th ed. Washington, D.C.
- Astwood, E.B., M.A. Greer and M.G. Ettlinger. 1949a. The antithyroid factor of yellow turnip. *Science* 109: 631.
- Astwood, E.B., M.A. Greer and M.G. Ettlinger. 1949b. L-5-vinyl-2-thiooxazolidone, an antithyroid compound from yellow turnip and from Brassica seeds. *J. Biol. Chem.* 181: 121-130.
- Bell, J.M. and E. Baker. 1957. Growth depressing factors in rapeseed oil meal. II. Studies on counteraction by dietary supplements. *Can. J. Anim. Sci.* 37: 21-30.
- Bell, J.M. and R.J. Belzile. 1965. Goitrogenic properties. P. 45-60 in *Rapeseed meal for livestock and poultry - a review*. Can. Dep. Agr. Pub. 1257, Ottawa, Canada.
- Blakely, R.M. and R.W. Anderson. 1948. Studies with rapeseed oilcake meal. I. The effect of various levels of rapeseed oilcake meal on the weight of thyroid glands of turkey poults. *Sci. Agr.* 28: 393-397.
- Bowland, J.P. 1965. Feeding value of rapeseed meal for swine. P. 69-80 in *Rapeseed meal for livestock and poultry - a review*. Can. Dep. Agr. Pub. 1257, Ottawa, Canada.
- Bowland, J.P. and J.F. Standish. 1966. Growth, reproduction, energy digestibility, nitrogen and Vitamin A retention and organ weights of rats fed solvent-extracted rapeseed meal or supplemental thioracil. *Can. J. Anim. Sci.* 46: 1-8.
- Chesney, A.M., T.A. Clawson and D. Webster. 1928. Endemic goitre in rabbits. I. Incidence and characteristics. *Bull. Johns Hopkins Hospital.* 43: 261-277.
- Clandinin, D.R., Ruth Renner and A.R. Robblee. 1959. Rapeseed oil meal studies. I. Effects of variety of rapeseed, growing environment and processing temperatures on the nutritive and chemical composition of rapeseed oil meal. *Poultry Sci.* 38: 1367-1372.
- Clandinin, D.R. and Louise Bayly. 1960. Rapeseed oil meal studies. II. Effects of feeding rapeseed oil meal on the structure of the thyroid glands of chickens. *Poultry Sci.* 39: 1239-1240 (Abstr.).
- Clandinin, D.R. 1967. Nutrient composition of expeller, prepress-solvent and solvent processed rapeseed meals. *Poultry Sci.* 46: 1596-1597.

- Dow, D.S. and C.E. Allen. 1954. Rapeseed oil meal in broiler rations with observations on the nature and control of its metabolic inhibitors. *Can. J. Agr. Sci.* 34: 607-613.
- Drouliscos, N.J. and J.P. Bowland. 1969. Biological evaluation of rapeseed meal, soya-bean meal and casein fed to weanling and the mature rat. *Brit. J. Nutrition.* 23: 113-123.
- Ettlinger, M. and A. Kjaer. 1967. Sulfur compounds in plants, p. 59 - 144 in *Recent advances in Phytochemistry*, (edited by T.J. Mabry, R.E. Alston and V.C. Runeckles). publ. Appleton - Century-Crofts, New York.
- Finlayson, A.J. 1965. Amino acid recoveries in the analysis of some feed samples. *Can. J. Plant Sci.* 45: 184-186.
- Frölich, A. and F. Haring. 1937. Use of rape residues as protein food for breeding sows. *Ztschr. Schweinezucht* 44: 533-534. (Nutrition Abstr. Rev. 16: 4206, 1938).
- Greer, M.A. 1956. Isolation from rutabaga seed of progoitrin, the precursor of the naturally occurring antithyroid compound, goitrin (L-5-vinyl-2-thiooxazolidone). *J. Am. Chem. Soc.* 78: 1260-1261.
- Greer, M.A. 1962. P. 187-219 in *Recent progress in hormone research. XVIII.* Academic Press, New York.
- Griesbach, W.E. and H.D. Purves. 1943. Studies on experimental goitre. V. Pituitary function in relation to goitrogenesis and thyroidectomy. *Brit. J. Exp. Path.* 24: 174-184.
- Hussar, N. and J.P. Bowland. 1959. Rapeseed oil meal as a protein supplement for swine and rats. I. Rate of gain, efficiency of food utilization, carcass characteristics and thyroid activity. *Can. J. Anim. Sci.* 39: 84-93.
- Kennedy, T.H. and H.D. Purves. 1941. Studies on experimental goitre. I. The effect of Brassica seed diets on rats. *Brit. J. Exp. Path.* 22: 241-244.
- Kjaer, A. 1960. *The Chemistry of Organic Natural Products*, P. 122. Springer-Verlag, Vienna.
- Klain, G.J., D.C. Hill, H.D. Branion and J.A. Gray. 1956. The value of rapeseed oil meal and sunflower seed oil meal in chick starter rations. *Poultry Sci.* 35: 1315-1326.
- Manns, J.G. and J.P. Bowland. 1963a. Solvent-extracted rapeseed oil meal as a protein source for pigs and rats. I. Growth, carcass characteristics and reproduction. *Can. J. Anim. Sci.* 43: 252-263.

- Manns, J.G., J.P. Bowland, V.E. Mendel and S. Zivkovic. 1963b. Solvent-extracted rapeseed oil meal as a protein source for pigs and rats. III. Blood serum protein bound iodine, standard metabolic rates, thyroid activity, adrenal and gonad weights. Can. J. Anim. Sci. 43: 271-278.
- Mustakas, G.C., L.D. Kirk and E.L. Griffin, Jr. 1962. Mustard seed processing: bland protein meal, bland oil, and allyl isothiocyanate as a by-product. J. Amer. Oil Chem. Soc. 39: 372-377.
- National Academy of Sciences - National Research Council. 1964. Nutrient requirements of domestic animals. No. 2. Nutrient requirements of swine, publ. 1192, Washington D.C.
- National Academy of Sciences - National Research Council. 1968. Nutrient requirements of domestic animals. No. 2. Nutrient requirements of swine, publ. 1599, Washington, D.C.
- Purves, H.D. 1943. Studies on experimental goitre. IV. The effect of diiodotyrosine and thyroxine on the goitrogenic action of Brassica seeds. Brit. J. Exp. Path. 24: 171-173.
- Robblee, A.R. 1965. Status of rapeseed meal as a protein supplement. P. 93-96 in Rapeseed meal for livestock and poultry - a review. Can. Dep. Agr. Pub. 1257, Ottawa, Canada.
- Schuld, F.W. 1967. Rapeseed meal as a protein source for swine reproduction. M.Sc. Thesis. The University of Alberta, Edmonton, Alberta.
- Schuld, F.W. and J.P. Bowland. 1968. Dietary rapeseed meal for swine reproduction. Can. J. Anim. Sci. 48: 57-64.
- Steel, R.G.D. and J.H. Torrie. 1960. Principles and Procedures of Statistics with Special Reference to Biological Sciences. McGraw-Hill Book Company, New York.
- Virtanen, A.I. 1965. A review study on organic sulphur components and other labile substances in plants. Phytochemistry 4: 207-228.
- Wetter, L.R. 1955. The determination of mustard oils in rapeseed meal. Can. J. Biochem. Physiol. 33: 980-984.
- Whiting, F. 1965. Feeding value of rapeseed meal for ruminant animals. P. 61-68 in Rapeseed meal for livestock and poultry - a review. Can. Dep. Agr. Pub. 1257, Ottawa, Canada.
- Witz, W.M., M.M. Carpenter and J.W. Hayward. 1950. Nutritional studies with rapeseed meal. Poultry Sci. 29: 786 (Abstr.).

APPENDIX A

Analysis of Variance at $P = 0.05$ level, for means in Table 4, page 19.

Daily feed, kg, from 83 kg liveweight to 1st breeding

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	0.0096	N.S.
Error	26	0.0382	

Daily gain, kg, from 83 kg liveweight to 1st breeding

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	0.0100	N.S.
Error	26	0.0278	

Feed required per kg gain, from 83 kg liveweight to 1st breeding

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	3.4940	N.S.
Error	26	3.1139	

Daily gain, kg, during 1st gestation period

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	0.0047	N.S.
Error	26	0.0065	

Feed required per kg gain, during 1st gestation period

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	0.5238	N.S.
Error	26	0.7392	

Daily gain, kg, during 2nd gestation period

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	0.0112	N.S.
Error	24	0.0140	

Feed required per kg gain, during 2nd gestation period

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	8.4046	N.S.
Error	24	10.2297	

APPENDIX B

Analysis of Variance at P = 0.05 level, for means in Table 5, page 22.

Number of services to conception

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	0.1794	N.S.
Error	26	0.1126	

Breeding weight, kg

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	32.7690	N.S.
Error	26	141.4959	

Total gestation weight gain, kg

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	102.8877	N.S.
Error	26	75.6463	

Lactation weight loss, kg

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	10.9351	N.S.
Error	26	70.7457	

Number of pigs born

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatment	3	2.5544	N.S.
Error	26	5.2232	

Number of pigs born live

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	5.0258	N.S.
Error	26	5.1188	

Number of pigs weaned

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	2.9651	N.S.
Error	26	9.6950	

Litter birth weight, kg

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	7.2168	N.S.
Error	26	8.7447	

APPENDIX B (cont'd)

Analysis of Variance at $P = 0.05$ level, for means in Table 5, page 22.

Litter weaning weight, kg

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	52.2679	N.S.
Error	26	150.5606	

Pig birth weight, kg

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	0.0176	N.S.
Error	26	0.0282	

Pig weaning weight, kg

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	0.5125	N.S.
Error	26	1.2984	

APPENDIX C

Analysis of Variance at $P = 0.05$ level, for means in Table 6, page 24.

Number of services to conception

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	0.1210	N.S.
Error	24	0.1277	

Breeding weight, kg

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	166.8770	N.S.
Error	24	282.6686	

Total gestation weight gain, kg

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	144.7381	N.S.
Error	24	182.0744	

Length of gestation, days

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	2.0536	N.S.
Error	24	2.2716	

Lactation weight loss, kg

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	49.9127	N.S.
Error	24	99.7133	

Number of pigs born

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	7.3770	N.S.
Error	24	8.7728	

Number of pigs born live

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	6.1448	N.S.
Error	24	8.3033	

Number of pigs weaned

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	7.5714	N.S.
Error	24	6.8452	

APPENDIX C (cont'd)

Analysis of Variance at $P = 0.05$ level, for mean in Table 6, page 24.

Litter birth weight, kg

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	20.3832	N.S.
Error	24	12.6065	

Litter weaning weight, kg

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	172.0508	N.S.
Error	24	181.0266	

Pig birth weight, kg

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	0.0422	N.S.
Error	24	0.0538	

Pig weaning weight, kg

<u>Source</u>	<u>df</u>	<u>M.S.</u>	
Treatments	3	1.3952	N.S.
Error	24	0.8626	

APPENDIX D

Analysis of Variance at ($P = 0.05$)* level, for means in Table 7, page 26.

Daily gain (83 kg to 1st breeding), kg

<u>Source</u>	<u>df</u>	<u>M.S.</u>
Treatments	3	0.0066
Breeds	1	0.1540*
Treatments x Breeds	3	0.0322
Error	22	0.0229

Weight at 1st breeding

<u>Source</u>	<u>df</u>	<u>M.S.</u>
Treatments	3	40.5312
Breeds	1	731.5312*
Treatments x Breeds	3	33.6146
Error	22	133.5114

Pig birth weight 1st cycle, kg

<u>Source</u>	<u>df</u>	<u>M.S.</u>
Treatments	3	0.0228
Breeds	1	0.1378*
Treatments x Breeds	3	0.0062
Error	22	0.0272

Weight at 2nd breeding, kg

<u>Source</u>	<u>df</u>	<u>M.S.</u>
Treatments	3	231.3646
Breeds	1	2610.0312*
Treatments x Breeds	3	113.5312
Error	20	213.6875

Pig weaning weights, 2nd cycle, kg

<u>Source</u>	<u>df</u>	<u>M.S.</u>
Treatments	3	1.4170
Breeds	1	4.5*
Treatments x Breeds	3	1.6025
Error	20	0.6685

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